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Commercial materials and equipment are identified in this report to specify the experimental procedure. Such identification does not imply official recommendation or endorsement or that the equipment and materials are necessarily the best available for the purpose.

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## PARTIAL DENTURE ALLOY-DENTURE CLEANSER INTERACTION

The daily cleansing of removable dental prostheses is an important facet of oral health maintenance for edentulous and partially edentulous patients. Although a vast spectrum of cleansing procedures can be employed for the removal of acquired stains and deposits from polymeric and metallic dentures, most patients express preference for the exclusive use of immersion-type cleansers.

Previous reports<sup>1-5</sup> have indicated that some denture cleansing solutions provoke deleterious alteration of the metallic components of removable dental prosthetic devices. Such changes, which include permanent discoloration, clasp fracture and subtotal dissolution of chromium-containing partial denture frameworks are sequelae of electrochemical phenomena.<sup>6-8</sup>

The present investigation was conducted to characterize the electrochemical behavior of three specific base metal partial denture casting alloys in widely used cleansing agents.

### - Materials and Methods

A cobalt (~61%)-chromium (~32%) alloy,<sup>\*</sup> a cobalt (~52%)-chromium (~27%)-nickel (~16%) alloy<sup>+</sup> and a nickel (~70%)-chromium (~16%) alloy<sup>#</sup> were used as solutes and subjected to testing in five cleanser preparations. Test media included a sodium hexametaphosphate<sup>§</sup>-sodium hypochlorite<sup>¶</sup> solution, three

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\* Vitallium<sup>2</sup>, Howmedica, Inc., Dental Div., Chicago, IL 60632.

+ Durallium LG, J. F. Jelenko & Co., Penwalt Corp., Armonk, NY 10504.

# Ticonium Premium 100, Ticonium Co., Albany, NY 12207.

§ Calgon, Consumer Products Co., Inc., Pittsburgh, PA 15230

¶ Clorox, The Clorox Co., Oakland, CA 91604.

proprietary alkaline peroxide denture cleansers<sup>Ω</sup> and a newly marketed acid-based liquid cleanser.<sup>Π</sup>

Alloy-specimens were cast by means of conventional lost-wax dental laboratory procedures. Each casting was a 1 mm X 12 mm rod with an enlarged rhombic shaped end. The cylindrical portion of each specimen was polished with 240 to 600 grit metallurgical papers, cleansed ultrasonically in detergent, rinsed with water and air dried. The rhombic portion of each casting was inserted into the split end of a 6-mm diameter copper tube. Specimen-tube contact was maintained by a force-fitted, wax-sealed Teflon sleeve.

Sodium hexametaphosphate-sodium hypochlorite solution was made by dissolution of the hexametaphosphate (2 parts by volume) and the hypochlorite (1 part by volume) in water (50 parts by volume). Aqueous solutions of the alkaline peroxide and acid-based cleansers were prepared in accordance with manufacturers' instructions.

The copper tube-cast specimen assembly was lowered into a glass corrosion cell to a depth that allowed complete immersion of the cylindrical portion of the casting in 500 ml test medium. For one series of experiments, changes in potential (mv) of the alloy-specimen (working electrode) relative to that of a saturated calomel electrode (SCE) were monitored continuously over an eight-hour period with the use of a potentiostat/galvanostat<sup>\*\*</sup> and a Cartesian coordinate recorder.<sup>++</sup> For all experimental trials, temperature of the medium (solvent) was maintained at 25 ±2C. Data from a minimum of three trials in each medium were averaged for the construction of composite plots of open

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Ω Polident, Block Drug Co., Inc., Jersey City, NJ 07950; and Effident, Warner-Lambert Co., Morris Plains, NJ 07950; and Mersene, Colgate Palmolive Co., New York, NY 10022.

Π 4 Minute, Dent-Mat, Inc., Santa Maria, CA 03456.

\*\* Model 173, Analytical Instrument Division, Princeton Applied Research Corp., Princeton, NJ 08540.

++ X-Y Recorder, Model 8110 BR, Bascom-Turner Instruments, Newton, MA 02154.

circuit potential versus time.

Specimens allotted to a second series of experiments were subjected to potentiodynamic cyclic polarization in each test medium. The cycle was initiated at -1.0V versus a saturated calomel electrode (SCE) by application of a potential of -1.0V to the counter electrode of the corrosion cell. Each specimen was polarized anodically at a rate of 0.01V per sec with the use of a programmable potentiostat.<sup>##</sup> Polarization was allowed to proceed anodically until an increase in current density of approximately 3 decades was experienced by the working electrode. Then the direction of change of the impressed potential was reversed. Completion of the polarization cycle was marked by return of the specimen to a potential of -1.0V versus SCE.

Plots of changing current density versus impressed potential yielded cyclic polarization diagrams. The significant features of a cyclic diagram are shown in Figure 1. Anodic behavior is depicted by solid line AB. The reduction (cathodic) phase of the cycle is illustrated by the broken lines. Equilibrium of the solute-solvent redox system is marked by intersection of the cathodic reduction and anodic dissolution curves. Locations of the intersections of cathodic curves CD, EF and GH with the anodic curve reflect alloy equilibrium conditions of strong passivity (solute protected by a stable oxide film from further attack by solvent), weak passivity and activity (vigorous attack of solute by solvent), respectively.

### Results

The open circuit profiles of the base metal partial denture alloys are presented in Figures 2-6. The range of initial potentials was delineated by the interaction of Ticonium 100 with Mersene (-500 mv vs SCE) and Durallium LG with Calgon-Clorox (0 mv vs SCE).

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<sup>##</sup> Universal Programmer, Model 175, Analytical Instrument Division, Princeton Applied Research Cor., Princeton, NJ 08540.

In Calgon-Clorox, Durallium LG and Vitallium exhibited a slight tendency to reach more noble potentials (Fig. 2). However, Vitallium first experienced increased electronegativity. The interactions of the two cobalt-containing materials with the other cleansers were characterized by increased alloy activity as a function of time.

The overall behavior of Ticonium 100 in Calgon-Clorox (Fig. 2), Mersene (Fig. 3), Polident (Fig. 4) and Effedent (Fig. 5) was typified by decreased electronegativity. In 4 MINUTE cleanser, the open circuit potential of the nickel-chromium alloy became increasingly negative (Fig. 6).

The equilibrium conditions of the alloys as determined by cyclic polarization are noted in the table.

#### Discussion

The interactions of partial denture alloys (solutes) with cleanser solutions (solvents) are manifestations of compositional and structural features of the alloys and the oxidizing power of the cleansers. The corrosive nature of most proprietary denture cleansers is attributed mainly to their inordinately high chloride ion content.

For the safe cleansing of a removable prosthesis, alloy-cleanser interactions must favor the spontaneous formation of stable films upon the alloy's exposed surfaces. Such films render active and corroding substances passive i.e., relatively impervious to continued destructive dissolution.

Under simulated conditions of temporary storage, spontaneous active-passive transition was not a feature of the electrochemical behavior of the cobalt-based materials, Durallium LG and Vitallium. The decreased activity of these alloys that accompanied prolonged immersion in Calgon-Clorox appeared to be related to degeneration of an unstable hypochlorite solution and concomitant chloride ion dissipation.

The demonstrated ability of Ticonium 100 to reach a passive state when exposed to four of the five test cleansers should not be construed as definitive evidence of metal denture framework-cleanser compatibility. It must be pointed out that the compositional features of wrought direct retainers (clasps) as well as those of solders used for the attachment of such pieces to a cast framework differ greatly from the compositional features of the nickel-based casting alloy. Galvanic couples formed by the union of dissimilar metals are likely to be highly susceptible to corrosive attack by denture cleansers.

Prudence dictates that extreme care should be exercised in the routine cleansing and temporary storage of metallic denture prostheses. The frequent rinsing of removable appliances in water and their occasional cleansing in either a mild household detergent or a dilute vinegar-water solution are practical and acceptable alternatives to the habitual use of so-called denture cleansers.

#### Summary

The electrochemical behavior of three partial denture casting alloys was studied. Under simulated conditions of denture storage, only one test alloy exhibited spontaneous active-passive transition. The findings contraindicate the use of five widely used materials for the immersion cleansing of cobalt-based removable partial denture frameworks.

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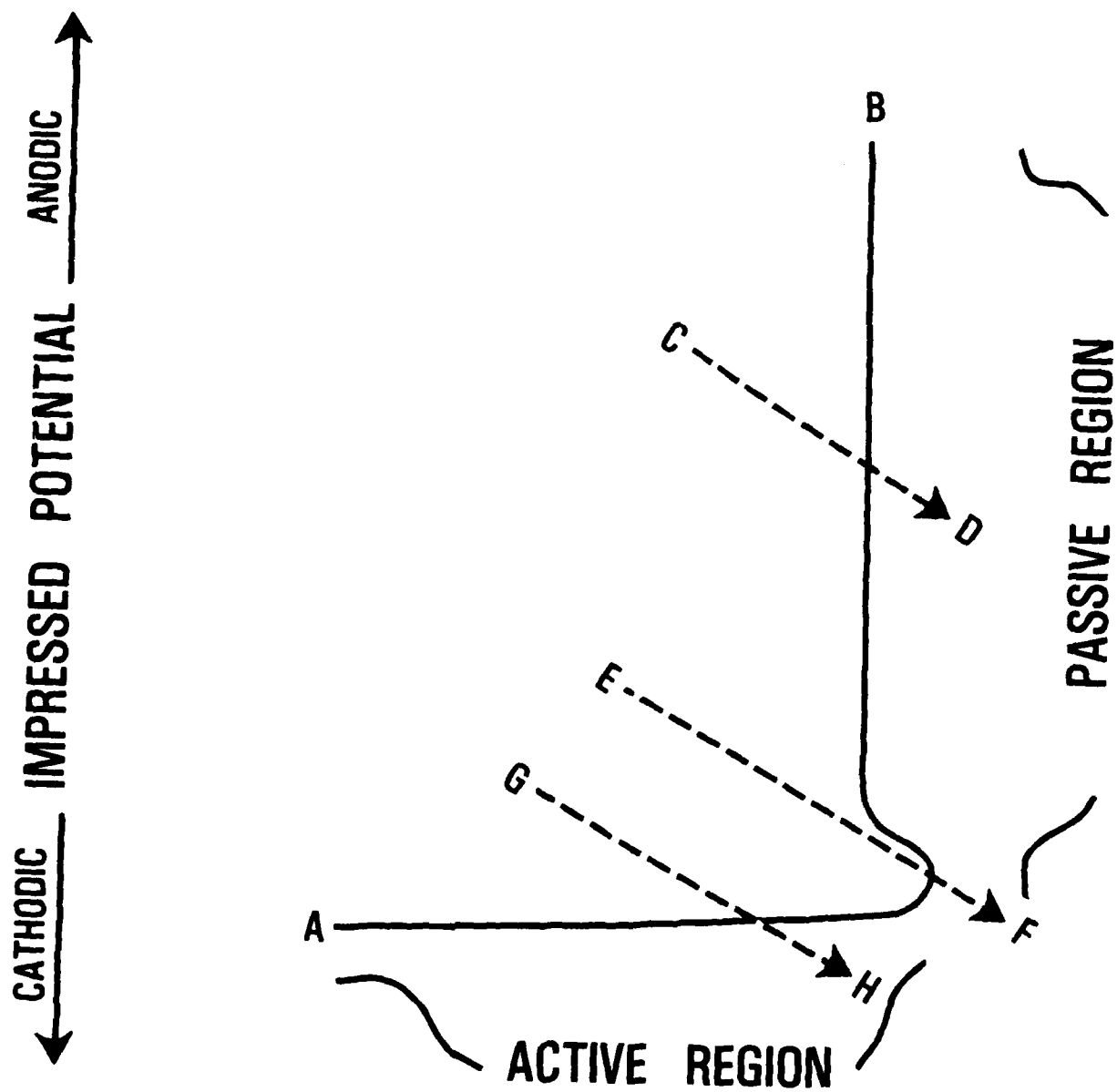
# CYCLIC POLARIZATION FINDINGS

Cleanser Solution	Ticonium 100 Equilibrium Condition	Vitalium Equilibrium Condition	Duralium LG Equilibrium Condition
Calgon-Clorox	Weakly passive	Active	Active
Mersene	Weakly passive	Active	Active
Polident	Strongly passive	Active	Active
Efferdent	Strongly Passive	Active	Active
4 Minute	Active	Active	Active

### Legends for Figures

- Figure 1. Schematic cyclic potentiodynamic polarization diagram.
- Figure 2. Open circuit profiles of partial denture alloys: Solvent, Calgon-Clorox.
- Figure 3. Open circuit profiles of partial denture alloys: Solvent, Mersene.
- Figure 4. Open circuit profiles of partial denture alloys: Solvent, Polident.
- Figure 5. Open circuit profiles of partial denture alloys: Solvent, Effident.
- Figure 6. Open circuit profiles of partial denture alloys: Solvent, 4 Minute cleanser.

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